

AT THE ENTERPRISES AND INSTITUTES

UDC 666.3:535.581

THERMOSTATTING THE INSTRUMENT FOR REGISTERING HEAT-TREATED PRODUCT PARAMETERS AT ELEVATED TEMPERATURES

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Two variants of thermostats for measuring instruments are developed and tested. The temperature from 5 to 50°C required for normal operation of the instrument is maintained during the entire time the thermostat stays inside the drier, i.e., 43 h.

In view of increasing competition between producers of ceramics, the consumers' requirements on product quality have recently grown. This is reflected in scientific papers discussing production methods, energy-saving activities, and optimization of drying and firing processes [1–5]. The only reliable method of testing efficiency of proposed innovations is conducting industrial experiments. The requirements on the accuracy and reliability of experimental data are becoming more stringent as well.

The quality of experimental research can be substantially improved using state-of-the-art mathematical methods such as experimental design theory and using new instruments for measuring and recording technological parameters. The new instruments include computer monitoring of technological processes. However, information on the new generation of instruments is insufficient and the data reliability of some manufacturers' catalogs leaves much to be desired. Such situation is likely to persist for some time. Consequently, describing the experiments of using particular contemporary instruments or new methods for their integrated use is going to be useful.

The present paper is dedicated to the possibility of using new multichannel sensors and monitors of technological parameters under increased temperature by means of placing these secondary instruments in a special thermostat cooler. Owing to this technique, one can carry out continuous monitoring of the temperature and moisture of raw bricks at many points of the brick charge and heat carrier (hot air) while the car with the products moves along the drying tunnel.

The particular formulation of this problem consists in designing a thermostat cooler that could maintain temperature from 5 to 50°C needed for the functioning of the instrument.

A known scheme of registering heat-treated product parameters consists of gages and a recording instrument connected by electric cables. Usually gages are located directly on the products, whereas the measuring instrument is removed from the working space of the furnace and installed outside under conditions admissible for its normal operation.

The disadvantage of this scheme is the impossibility of continuous monitoring of the parameters of heat-treated products moving inside the furnace with an elevated temperature of the working space. This is due to the difficulty of coupling the gages placed on products moving inside the furnace with the outside instrument, especially if the products move along a complex route or if the working space of the furnace is long (a few dozens meters) as is the case in tunnel driers and furnaces. The measuring and recording instrument cannot be placed inside the working space of the furnace due to its elevated temperature (above 50°C) which the instrument cannot withstand.

To ensure long-term self-contained monitoring and recording of parameters of heat-treated articles under elevated temperatures, it is proposed to place the measuring and recording instrument in a heat-insulated thermostat chamber that also contains a cooling agent, while the gages as usual are placed in heat-treated products.

The cooling agent occupies the lower part of the thermostat chamber. Due to heat absorption under phase transformations and its own heat consumption, the coolant maintains the temperature inside the chamber within the temperature interval admissible for the power source and the instrument. The quantity of the coolant is calculated based on the thermal balance of the thermostat chamber and then refined experimentally depending on the admissible operating temperatures of the instrument and the power source, the type of the coolant (water, dry ice, etc.), the temperature in the working

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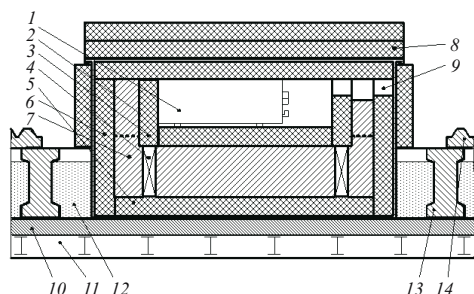


Fig. 1. Scheme of thermostat with two steel containers.

space of the furnace, the type and the thickness of thermal insulation, the process duration, etc.

Two variants of thermostat have been developed. The first one has a rigid structure in the form of two steel containers, one inside the other. The second variant has wooden walls and ensures a longer service.

Figure 1 shows the scheme of a thermostat with two containers installed on a drying car to register the parameters of heat-treated products at elevated temperatures.

Measuring instrument 1 together with a power source (not shown in the figure) is inside steel container 2 with inner heat insulation made of foam plastic 3. The containers relies on wooden spacers 4 that are place on foam-plastic heat-insulating layer 5 inside outer metal container 6. The space below between the wooden spacers and along the sides of inner container 2 is filled with coolant agent 7. The outer container has a metal lid and is covered on top and on its sides with a layer of foam-plastic insulation 8. Opening 9 for cables connecting the instrument with the gages passes through containers 2 and 6 and through heat insulation layers 3 and 5. The thermostat is placed on heat insulation layer 10 over the steel car frame 11 instead of partly removed powder charge 12 between the supports 13 of ceramic plates 14, on which bricks are placed for drying.

This two-container thermostat structure ensures a reliable separation of the instrument and the power source from the coolant. Testing performed in industrial conditions in a tunnel brick drier produced by the Fuchs Company indicates that as the thermostat moves on the car together with the brick along the drier, the temperature inside it for about 24 h keeps acceptable for the instrument. The experiment identified temperature variations next to the instrument inside the thermostat. Temperature dependences were obtained using a TL-01 autonomous miniature temperature monitor produced at the Sistemotekhnika JSC (city of Ivanovo). The monitor registers the ambient temperature each 2 min for nearly 3 days. It has proved reliable under heavy duty [6]. Accumulated data are transmitted from the internal memory of the TL-01 monitor to a PC memory using a simple and reliable program via an adapter cable (RS-232 standard). The data can be displayed on a computer or printed in the form of a table, a graph, or a histogram.

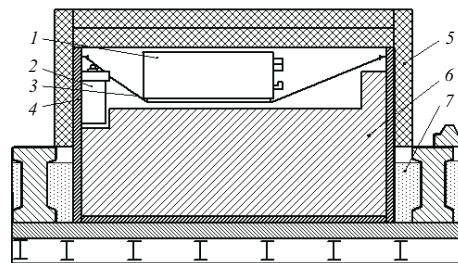


Fig. 2. Scheme of thermostat with a wooden chamber installed on a car.

Temperature variations inside the inner container of the thermostat placed directly on the car plates were registered as well. It was found that the temperature persists at a low level only for the first 7 h, after which starts intensely growing and continues for 23 h with a decelerating rate up to the level of 48°C.

When the thermostat is inserted in the bottom of the car as shown in Fig. 1, the temperature grows slower. However, in this case as well acceptable temperature persist for only slightly more than 24 h.

In order to extend the work of the thermostat to a longer period (40 – 48 h), the following design modifications were made based on the above experimental results:

- the steel case was replaced by a wooden one (to decrease thermal conductivity);
- the thermostat size was increased to a maximum dimension admissible by the space between the supports of the plates on the car;
- the weight of the coolant agent was significantly increased at the expense of both increasing the dimension of the outer container and by abandoning the idea of the inner container together with its heat insulation.

The scheme of the second variant of thermostat inserted into the car bottom is shown in Fig. 2.

In general the set for measuring and registering parameters of heat-treated products under elevated temperatures consist of gages inserted into heat-treated products with connecting cables located in the working space of the drier, as well as the measuring and registering instrument.

Measuring instrument 1 together with power source 2 is placed on suspension 3, which ensures its fast installation and removal, in the upper part of heat-insulated wooden chamber 4 with a lid and outside lateral walls 5 made of a heat-insulating material. Cooling agent 6 is in the lower part of the chamber. The chamber together with heat insulation is lowered in the car bottom 7 so that the upper part of the chamber insulation be at the level of heat-treated products and not impede the loading and unloading of product via the working ports of the furnace.

This set for measuring and recording parameters of heat-treated products under increased temperature works as follows.

Before the start of the heat treatment cycle, sites for fixing pickups are prepared in products (for instance, a hole for the junction of a thermocouple, whereas a pit of a corresponding size is made in the furnace bottom or in the moving car next to heat-treated product, to install heat-insulated chamber 4 with instrument 1, power source 2, and coolant 6 inside.

A set consisting of a power source and the instrument connected with cables from the gages is prepared and tested beforehand. Before suspending the power source and instrument 1 with connected cable inside the thermostat chamber, coolant agent 6 is placed in the lower part of chamber 4. After the instrument with power source is installed on suspension 3 inside chamber 4, the operating of the whole set is checked and the instrument is switched to the mode of registering parameters. Chamber 4 is covered with heat-insulated lid 5, which has an opening for the cable connected with the gages. In doing this, the hole for the cable in the lid is heat-insulated as well.

The measuring set assembled in this way is brought to the site of installation and lowered into the prepared pit in the car bottom. The gages are fixed in the prepared openings in heat-treated products and the whole measuring set together with the products on the car equipped with gages is pushed into the furnace.

During heat-moisture treatment the instrument keeps monitoring and records the values of monitored parameters with a preset time interval. After the end of the process, heat-insulated chamber 4 is taken out from the pit and the gages are removed from heat-treated products. The measuring set is transferred to a separate room and disassembled, the data from the inner memory of the instrument are transmitted to a computer for storage and processing in the form of tables and plots.

As a result of measuring temperature inside the thermostat, it was established that it varied from 10 to 31°C and on the average was equal to 17.5°C. It should be noted that after staying in the drier for 43 h the temperature in thermostat

was only 31°C and, accordingly, there was still time left until its rise to 50°C.

The thermostat is intended for coupling with 16-channel instrument IRT-4 that is manufactured since 2004 at the Praktik-NTs Research and Production Association (city of Zelenograd). The temperature monitor-controller IRT-4 has some disadvantages [6], but is the most promising among analogous domestic instruments regarding its technical characteristics and energy consumption.

Thus, the proposed set with a thermostat for measuring and registering parameters of heat-treated products at high temperatures ensure virtually continuous monitoring of needed parameters (for instance, temperature and moisture). Based on obtained data one can have objective information on the process, analyze the variations of parameters, and search for the optimum heat-treatment regimes by comparing real parameters and their variation rates with values recommended in the literature and the results of laboratory experiments.

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